BRITISH GUIANA BRANCH,

BRITISH MEDICAL ASSOCIATION.

PAPERS

BY

DR. G. C. LOW,

LONDON SCHOOL OF TROPICAL MEDICINE.

ON

MALARIA AND FILARIASIS.

GEORGETOWN, DEMERARA:

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SOME POINTS

ON THE RECENT RESEARCHES IN MALARIAL FEVER.

(Paper read by Dr. G. C. Low, before the British Guiana Branch, British Medical Association.)

In 1880, Laveran, then an Army Surgeon in Algiers, discovered the plasmodium of Malaria. Many people before that date had probably seen the parasite, but they failed to associate it with the fever, and passed it over as dirt or some degeneration due to artificial causes from drawing the blood. Laveran's discovery did not at first create much sensation, and that, although he went specially to Italy to demonstrate it. The Italians, however, though at first sceptical, quickly took the matter up, and Golgi on examining the blood of cases of malarial fever found similar parasites, and confirmed the fact that in the blood of people suffering from malarial fever, a definite organism or plasmodium was to be found. He further found that the parasites at first small, grew larger and larger, and eventually sporulated destroying the individual corpuscles, so allowing the spores to escape into the blood plasma, from whence they attacked new corpuscles and so completed the cycle. Laveran believed that there was only one form of parasite for all the types of fever, but Golgi again shewed that only one parasite was associated with a fever occuring on every third day, *i.e.* a tertian fever, one with a fever occuring every fourth day, a quartan fever, and another with a more or less irregular, sometimes intermittent or remittent fever of grave form, and to which the name malignant or *aestiro-autumnal* was given. In this latter, crescentic bodies were often seen, but their significance he could not then determine. Following up those discoveries many other Italian pathologists took the field, and Bignami and Marchiafava especially did good work at the subject. Taking cases in the hospital at Rome they worked out the whole of the clinical aspect of malarial fever, proved without doubt their relationship to the parasite, and also found that by inoculating a small quantity of malarial blood into a healthy person they could produce a typical attack of malarial fever, the type depending on which class of parasite they had used for the experiment. The pathology of the disease was gone into with special thoroughness, the implication of the spleen and liver with the peculiar pigmentation found there was clearly demonstrated, and the cause of death in pernicious comatose cases was found to be associated with a blocking of the cerebral capillaries with parasites. Somewhat later than this Mannaberg, an Austrian, again confirmed all these discoveries, and Celli and Bastianelli, the Italians, continued the work and found out other points of interest. Matters stood thus till 1894. Manson, being struck by the fact that on watching malarial blood for some time under the microscope, the gametes of tertian and quartan fever and the spheres or gametes of malignant fever proceed to flagellate, came to the conclusion that the function of the flagellated body must

be extra-corporeal, and was the first phase of the parasite in its life outside the human body. As the plasmodium could not, enclosed in the corpuscle, escape from the body on its own account, he came to the conclusion that some blood-sucking insect, namely mosquitos, were the means of abstracting the blood, and that certain species of this insect probably acted as intermediate hosts for the further development and extra-corporeal life of the malarial parasite. He was the more strongly convinced of this, because of the work he had already done in the case of *filaria nocturna*, where he shewed that the embryo of this parasite must pass through certain species of mosquitos to allow of their further development. The Italians at this time believed that the flagellation was not normal, and was only a degenerative stage. Ross, in India, working on the lines suggested by Manson, in 1895 demonstrated the fact that when mosquitos suck up blood containing crescents, many of the latter proceed to flagellate in the stomach and shed their flagellæ, and he further shewed two years later, that mosquitos of particular species (now known to be Anopheles) after feeding on malarial blood, exhibit pigmented and living parasites in their stomach walls. Unfortunately, at this time Ross could not get sufficient material for his researches on human malaria, so he began similar experiments with certain mosquitos on an allied blood parasite of birds, the proteosoma. This latter is found in the blood of many small birds, sparrows, larks, finches, &c., and in some ways resembles the human plasmodia. Working then on this, he found that when mosquitos of the *genus culex* are fed on infected birds, the parasites instead of being digested and destroyed, pass through the stomach walls, become attached on its outer surface, and there grow enormously in size. Changes go on inside those bodies, which have been named Zygotes, eventuating in sickle-shaped structures called Sporozoites. After some time the Zygote capsule ruptures, the sporozoites become free and pass into the salivary glands of the insect, and when the latter again bites a fresh bird they are inoculated into its blood so infecting it with the proteosoma. The importance of this discovery was enormous, as, together with the fact, already pointed out by the same author, of living and growing pigmented parasites in the stomach wall of anopheles fed on human subjects suffering from malaria, it proved by analogy that the malarial parasite could be spread from man to man by the agency of mosquitos.

Confirmation of this work came rapidly, the Italians again coming to the front with very able research. Grassi working in Rome found that species of anopheles especially *anopheles claviger* when fed on the blood of people containing the different plasmodia shewed almost exactly similar changes to those described by Ross for culex with the proteosoma of birds. He worked out the whole cycle separately for benign and malignant parasites and found that in both those the sporozoites eventually became lodged in the salivary glands. To make no doubt of the fact he and Bignami had a man who had never suffered from malarial fever, bitten by infected anopheles. This patient had been for some years in the *Sancto Spirito* Hospital in Rome where it is now very rare for any one to contract fever, and on a certain day he was bitten by the aforesaid infected mosquitos. About ten days afterwards he had a typical attack of fever with

parasites in his blood, and so the truth was reached that mosquitoes of certain genera could carry malaria from man to man. Grassi and the other Italians next tried different species of culex and found that those did not act as efficient hosts, and though many other insects have yet to be worked out individually, it is probably true that only mosquitos of the genus anopheles spread the malarial fever of man. Other experiments which I shall describe under the prophylaxis of the disease later, shew still more clearly that mosquitos are the only means of spreading the disease, other factors such as air and water being now entirely disproved.

The classification of malarial parasites:—

Since the recent researches on malaria have shewn that many different plasmodia are found in man and the lower animals, many of the latter closely resembling the former in shape and structure but being specifically distinct. Many more still remain to be found out and their proper intermediate hosts determined but the subject has already reached such large dimensions that the various authorities have attempted a special classification, and have put those parasites into a special family called the Hæmamœbidæ.

Starting then with the latter term so far we have under it two genera:—Genus I. Hæmamœba.

In this (genus) the mature gametocytes are similar in form to the mature sporocytes before the spores have been differentiated. Under this four different species of parasite are found namely,

1st Hæmamœba danielewskii, or what has been called halteridium —a parasite found in pigeons, jays and crows.

2nd Hæmamœba Relicta or Proteosoma—the parasite of sparrows and larks.

3rd Hæmamœba malariæ—the parasite of quartan fever in man.

4th Hæmamœba vivax—the parasite of Tertian fever in man.

Genus 2—Hæmomenas—

In this the gametocytes have a special cresentic form:—species 1 Hæmomenas Praecox.

The parasite of the irregular remittent pernicious or æstivo-autumnal fever of man. Several varieties of these are known and probably they will eventually be found to be distinct species.

Since this table was drawn out three new parasites very closely resembling those of man have been found by Dionisi in the blood of bats and these will have to be put under one or the other of the two genera. Of those (the bat parasite) two resemble the benign forms in man and one the malignant.

Turning now to the parasite of man, the classification of Mannaberg based on the works of the Italians is that now usually adopted. He divides them primarily into two large groups, the benign and the malignant. These two groups differ from each other both as regards their morphology and their clinical features.

Morphologically the benign parasites are large in size, their sporulating forms are common in the peripheral blood, their gametes appear similar to the large intra-corporeal parasites just before they

sporulate, whereas the malignant parasites are small in size, sporulating is rare in the peripheral blood, and their gametes take the form of crescentic or semi-lunar bodies. Clinically the benign parasites rarely if ever, give rise to malignant or pernicious symptoms, while with the malignant, such symptoms are frequent, and often give rise to fatal results.

The benign parasites are of two sorts, tertian and quartan, the former having a cycle of 48 hours, *i.e.* the fever appears every third day, whereas the latter has a cycle of 72 hours, the fever appearing every fourth day.

According to the Italian observers, the malignant parasites are three-fold:—a malignant tertian with fever every third day, the parasite being very small and generally shewing no pigment until just before sporulation, a malignant quotidian with daily fever, the parasite shewing as a minute ring with no pigment, and another malignant quotidian with similar fever but with the minute parasite shewing one or two minute black grains of pigment.

Arranging these according to Mannaberg we have:

Benign	Quartan Tertian	Do not form crescents.
Malignant	Quotidian pigd. Quotidian unpigmented Tertian	Form crescents.

The benign quartan parasite at its youngest stage is seen to be a small amœboid-looking body inside the red corpuscle, it grows larger gradually becoming pigmented, till it reaches its maximum size and then it breaks up into about ten spores, the corpuscle then disappears and the spores set free in the plasma invade fresh corpuscles, and so continue the intra corporeal cycle. Its gametes are similar to the large intra-corpuscular forms just before they divide up into spores, and may be recognised easily by the microscope. The benign tertian parasite starts in the same way and goes through a similar course of development, and its gametes are also the same. It may be distinguished from the former parasite by several definite characteristics, its amœboid movement is much more active, its pigment is much finer, its maximum size is that of a red corpuscle or very often it causes a distinct enlargement of the enclosing cell, its spores are more numerous averaging from 15 to 20, and clinically, of course, it is tertian in type.

In pure infections of either of these two parasites quinine rapidly causes their disappearance, though gametes may persist for some little time. Their geographical distribution is more sub-tropical than tropical.

The malignant parasites are much more difficult to see when examined microscopically; they take the form of minute rings with very active amœboid movements, watching such a ring in freshly drawn blood one can see a pseudopodium gradually shoot out, then another until the ring has changed into a star-shaped body, while with the same movement the parasite may move right across the corpuscle. In the pigmented forms one or two minute black specks of pigment are present inside the ring. The corpuscle in which the

parasite is enclosed may be normal in size or it may look degenerated and shrunken, and double or even treble infections of one corpuscle are very common. The sporulating stage is rarely seen in peripheral blood, the spleen and inner organs being the favourite site for this change to take place; and this consists of an increase in size of the parasite, a gradual appearance of an irregular heap of spores with several grains of pigment dancing in the centre, and then the corpuscle ruptures and the spores escape into the plasma. About ten days after an infection with malignant fever the gametes appear, taking the well known crescentic shape, but though the rings disappear in the administration of quinine, these seem to be unaffected and remain circulating in the blood for a considerable time, even after all traces of clinical fever have disappeared.

By preparing ordinary wet films of blood containing crescents, one can see a further stage appear, namely, the change of the crescent into the rounded body or sphere: This takes place in 10-20 minutes and eventually in several of those bodies which have now become hyaline in nature, and are really the male spheres, the pigment becomes very active and agitated, a little protrusion forms at the edge, and from this a flagellum suddenly appears, another may come out at another part of the sphere and so on till we have three or four; these after lashing about with great vigour break off into the plasma and their significance in the intra-corporeal stage of the parasite we will now enter into.

The Mosquito stage or Extra-corporeal stage of the Malarial Parasite.

If mosquitos of the genus anopheles feed on persons with gametocytes (*i.e.* the crescent of malignant fever or the spherical bodies of tertian and quartan fever), in their blood, certain definite biological changes resulting from the union of the male and female gametes take place. When the crescents come with the blood into the stomach of the mosquito they quickly change into spheres, some being hyaline the male element, while others are granular the female element.

The hyaline spheres as we have already seen in wet blood films shew increased activity of their pigment and quickly throw out flagellæ or microgametes. These break off, become free, move about in the plasma, seek out a granular sphere *i.e.* the female element or macrogamete: enter it and fertilise it, and thus we have the sexual act: the junction of the micro- and macrogamete, forming a single cell to which the name of zygote has been applied.

For some time this resultant body remains the same, but soon it elongates becoming at first oval then lanceolate, and in virtue of this change of shape it bores its way through the wall of the mosquito's stomach, coming to rest in the middle layer or muscular wall between the long and transverse fibres, where it remains after again becoming spherical and proceeds to develop.

Growth now goes on rapidly and two days after infection the body measures about seven *micromillimètres* shewing granular material and melanin particles in its interior. As the size increases the body pushes outwards disassociating the muscular fibres till it protrudes on the outer wall of the stomach like a small hernia. At the end of

five or six days it may measure about thirty *micromillimètres*, and changes now begin in its interior, the protoplasm dividing up and up to form many small round bodies which have been called zygotomeres. Those again in turn divide up and become transformed into similar round bodies called blastophores. About this time the sphere, which is really now a capsule with the contained elements, measures from thirty to forty *micromillimètres*, and soon several small straight spicule-looking bodies appear on the outer surface of the blastophore, the latter bodies now disappearing leaves the capsule packed with those spicules to which the term zygotoblasts or sporozoites has been applied measuring now about sixty *micromillimètres*, the capsule ruptures the sporozoites are set free into the tissues of the mosquito from whence they pass into the middle lobe of the salivary gland. When next the mosquito bites man some of those sporozoites are inoculated along with the saliva into his blood, passing from the plasma into the corpuscles and so completing the cycle.

It is thus seen that the malarial parasite has two cycles, an endogenous one and exogenous one. In the former the parasites reproduce themselves asexually in the human body by a division up of their protoplasm into spores, which in turn grow and re-divide and so continue the species: in the latter the sexual act appears and the changes take place in the stomach of mosquitos of the *genus anopheles*.

Starting then with the microgamete, the flagellum of the male gamete, we have this fertilising the female gamete or macrogamete, the resulting body being the zygote, which goes on to form the zygotomeres, then the blastophores, then the sporozoites which return to man via the proboscis of the mosquito, and so continue the species from man to man.

The scientific discovery of the propagation of malaria by means of certain mosquitos completely revolutionised the subject, and overthrew at one sweep many of the old ideas and theories as to its cause.

Before the brilliant suggestion of Manson, based on scientific grounds, as to the nature of the flagellæ and their probable extra-corporeal phase, and the subsequent work of Ross, many people had expressed the idea that there might be some connection between mosquitos and malarial fever. In parts of Italy the peasants thought that after being much bitten by insects they got fever and in Africa some Arabs and other tribes also associated the two together. King long ago thought that swamps might be dangerous owing to the many mosquitos which frequented those sites and Emin Pasha in his travels in Africa invariably slept under a mosquito net believing that this prevented him from getting fever. However apart from isolated instances like these, the general opinion was that it was due to the miasm arising from swamps or from drinking water from similar sites, the explanation of how it should arise so being left *sub-judice*, as malarial parasites had never been found in samples of air examined, and the Italians though making men in Rome drink gallons of water from the pontine marshes, a most malarious area, never got any positive results.

Once however the mosquito theory became an absolute fact, the explanation of those old factors in spreading the disease became clear.

Swamps and wet ground were found to be the favourite breeding grounds of hosts of mosquitos of the genus anopheles, the insects implicated in the spread of the diseases; and the prevalence of fever in such sites at once became evident.

In this matter of the epidemiology of malaria the Italians again quickly came to the front, having of course the most favourable advantages close at hand in the Roman Campagna.

As soon as the theory passed into fact, and the habits and breeding places of the dangerous mosquito became known, two points came up: could one destroy such insects in their larval or adult stage or could one protect in any way the fever-stricken inhabitants of the Campagna? The action of various chemical substances on the larvæ in water was tried by Celli in Italy, and by Ross and the other members of the malaria expedition to Sierra Leone. Both of those found that for localised action on small stretches of water kerosine oil acted in an efficient manner, but when the matter came to large collections of water it would not hold. At the same time however, in 1899 Celli protected with fine wire gauze netting two houses occupied by railway signalmen on one of the lines passing through the Campagna at a very malarious place called Ponte Galera; this latter experiment proved entirely successful the inhabitants passing through the fever season without suffering from a single attack.

In the following year the Colonial office on the suggestion of Dr. Manson organised a double experiment, namely that two people should live in a mosquito proof house in the Campagna during the fever season going about freely by day but returning in doors before sunset, and that mosquitos infected with malaria parasites from cases in Rome should be sent to London to bite healthy individuals to see if they would get fever or not. Both those experiments had already been done successfully by the Italians, but it was thought that their repetition by an English Commission would confirm them and lend additional proof to the English speaking colonies and places.—Dr. Sambon and myself, were sent out to Italy, taking with us a specially constructed house from England to erect in some part of the Campagna. We selected the most malarial place available, namely at the side of a swamp two miles from the ancient town of Ostia, and in lying the alluvial deposit near the mouth of the Tiber.

The house which had been sent out in parts, was fitted up and partook of the nature of a bungalow, the roof was high, and overlapping, leaving a large air space between it and the ceiling, and ventilated by a space running right round; trap door ventilators ran up through the roof communicating with the air space above. There were five rooms and a pantry: all the rooms, except one, having two windows allowing plenty of air to enter. The entrance was at one end by double doors, with a vestibule between, and this in turn opened into the corridor from which the doors of the rooms opened. All the apertures, i.e., windows, ventilators, panels of the doors which were open &c. were fitted with fine wire netting 1 mm. s.q.; and the windows had inside this mesh ordinary folding glass divisions which could be shut or opened at pleasure. The experiment was carried on in the fever

season of Italy i.e., in a time corresponding to the hot weather of those parts extending from June to the end of October, the period also when mosquitos are found in great abundance. The conditions one adopted were to go about freely during the day, retiring to the house some little time before sunset and remaining inside till the sun had risen next morning. As soon as the sun set many mosquitos quickly came round the gauze of the windows and remained about till next morning when they again disappeared; it was an exceedingly rare occurrence to see any anopheles through the day even in bushes, the swamp, or surrounding brushwood, and as far as Italy is concerned there was absolutely no danger of picking up fever by day. Three species of anopheles all capable of spreading malaria were found in the vicinity, viz.: anopheles claviger, pseudopictus, and bifurcatus: of these three, the latter two were sylvan in habits living in the woods on brushwood or jungle and not often being seen in the open, whereas the former was more or less domestic inhabiting peasants' houses, stables, hen houses, and similar sites in great abundance. Their larvæ abounded in the canals round the hut, and were also common in suitable pools of water in the centre of the bush, and in the open. Though these mosquitos slept in the ceiling of houses in large number especially in the dark and shady parts, often on old cobwebs, they did not descend to bite until just after sunset, and one could sit by day in safety in such places. The experiment turned out successfully, both of us, along with two servants, going through the season without any attack of fever and without being bitten by mosquitos none of which ever got into the house. In marked contrast to this was the case of the peasant inhabitants around, nearly all of whom suffered severely and especially two new factors who had come to the Campagna for the first time and who lived unprotected. All the inhabitants numbering seven, of a house about one hundred and fifty yards from the bungalow, suffered severely from fresh infections of fever one of the children being so bad that it had to be sent to the hospital in Rome, while the others exhibited severe or malignant symptoms. The cause was not far to seek as the house even by day was full of mosquitos and though the people used to shut their windows before sunset, a habit prevailing throughout the Campagna, it had no salutary effect as the mosquitos simply descended from the ceiling where they had been resting through the heat of the day.

The second part of the experiment was also successful; namely the infection of two Englishmen in London by the bites of anopheles which had fed on malarial cases in the hospital in Rome. Through the kindness of Pro. Bastianelli a large number of anopheles claviger bred from larvæ were fed on cases of benign tertian fever in the Sancto Spirito hospital; after feeding several times they were put in cylinders of gauze, which in turn were placed in wooden boxes with plenty of ventilation and then they were forwarded per rail to Ancona where they caught the English Mail from Brindisi. By this means they arrived in London in about 40 hours, and then they were met at Cannon Street station by an attendant and taken down to the London School of Tropical Medicine at the Albert Docks. They arrived home in good condition very few having died en route and they were then kept in artificially heated boxes till they were required for the experiment.

Two people, one the son of Dr. Manson, the other the laboratory assistant, were bitten by the insects and in about 10 days after, both these individuals developed typical attacks of benign malarial fever, one the case of Manson being double in type, the other the laboratory assistant being single. Three different lots of mosquitos were sent home at different times Manson being bitten by the first two batches, the assistant by the last only. It was thus again proved beyond doubt that malarial fever was due to bites of infected mosquitos, and that provided one kept free of such causes, air and residence in the climate though intensely malarious were not detrimental to health. During the same summer the Italians were experimenting also in malarious parts of Italy on a large scale, Prof. Celli taking the district of the Campagna round Rome, and Prof. Grassi that of Grosseto near Naples. These experiments were carried out in the houses of the railway servants and other people connected with the lines of rail and took the form of a thorough protection with mosquito wire-netting. In Italy there are little stone houses generally with two stories, placed at a distance of about one kilomètre right along the whole distance of the railway lines and it was on those houses, in the flat malarial ground, that those two observers worked at. Prof. Grassi had about 200 people under protection and out of this number only two showed symptoms of fever at the end of the season these having acquired it by being out at nights.

Professor Celli's work on similar lines was very interesting Taking the line from Rome to Tivoli the tract runs through the Campagna for about 15 miles till it rises up into the mountains to a considerable height above sea level into a region free from malaria. In its course to Tivoli twenty or more houses for signalmen and workers looking after the line are situated, well built stone houses with little gardens round them. In the old days the expense to the railway companies was enormous, the people inhabiting these houses dying off in one or two seasons and requiring double wages before they would risk their lives in living in such an unhealthy area—Celli's protecting experiments took the form of windows for these houses with wire gauze netting, and building verandahs of similar material outside the main door with automatically closing doors for the people to sit out in the evenings. The results again were similar all the people passing through the fever season in perfect health, perfectly free from fever, the men who had to go out at night to work being specially protected with veils made of gauze, and gloves. In several cases test houses, i.e., houses unprotected were left to see to what extent the inhabitants would suffer and in those cases malarial fever was as rife as ever, all the inhabitants having many attacks.

From these experiments it is therefore evident that if one can avoid being bitten by mosquitos, and so far as is known at present by mosquitos of the genus anopheles : one can live in intensely malarious regions with perfect safety.

Now that it is known where the danger of malarial fever comes from, what can be done to prevent, diminish or to stamp it out ?

Theoretically speaking if one could cut the chain at any part of the cycle i.e., stamp out malarial parasites in man, or completely des-

troy anopheles mosquitos, malarial fever would cease to exist ; but of course, practically speaking, either [of these two alternative is impossible and especially so in the tropics. It is not by taking up any one line, but by taking a judicious combination of all the factors known to be detrimental to the spread of malaria, that good can be hoped for.

Prof. Koch in his reports of the German malarial commission advocates strongly the treatment of everyone with quinine and he considers that there is hope for a great diminution of malarial fever thereby.

This study of the intra-corporeal phase of the parasite in man is of course of great importance, especially as quinine is at the same time the only drug of any value in treating malarial fever ; but the difficulty of thoroughly carrying it out and the expense of the drug itself will always prevent much being done in this line. Christopher and Stevens have shown that the great source of infection of Europeans in the West Coast of Africa is from native children, who though presenting no symptoms of the disease, yet have their blood full of parasites. Unless quinine is given in adequate doses and kept up for long periods of time it will not prevent the gametes or infecting agents being presen t in the blood and the difficulty, in fact one may, say the impossibility of getting natives spread over large areas to appreciate such a point and to get them to take medicine systematically, is patent to all. However, though much cannot be hoped for in a general way, it is exceedingly important that all white people, especially in small districts and ports in the tropics, should on getting fever be thoroughly and systematically treated by quinine both for their own good and for the good of their neighbours whom they may infect. Grassi in Italy hopes to help the diminution of fever greatly by the systematic dosing with quinine; but then the people there are civilised, and thoroughly appreciate the dangers of the disease, and the government are doing their best by gratuitously giving quinnie as far as possible.

The next point, the destruction of mosquitos is of great importance, but here again one must not be too sanguine and ever expect to be able to entirely rid a tropical country of these pests; it is only the application of the principle applied locally and in favourable circumstances and places that will eventually cause a limited success.

The great factor in the destruction of mosquitos is the abolition of their breeding places, and places where this is practicable will become free of fever, whereas those where it is not will continue to suffer. Since parts of the Campagna in Rome have been thoroughly drained there has been a great diminution of fever, and more may be hoped for, though the problem of dealing with swamps like Ostia and Maccarese which are below sea level, and which cant be absolutely dried up, is very difficult, just as is the case in so much of the land in British Guiana.

To take a very local instance, no one now should have stagnant pools near ones house, those being either filled up or periodically treated by kerosene ; every one about to build a fresh house or found a new station or village should in the light of modern research choose an

elevated place if possible with no stagnant collection of water near or if such exist that can be easily drained. Little minor points like this will make all the difference as regards ones health and comfort. Wherever possible sanitation should advance and drainage be carried out, many notoriously malarial places could really with very little difficulty be rendered almost free. The town of Castries in St. Lucia is such a place, shut in by an amphitheatre of hills, the whole source of the fever is in a small area round the outskirts of the town and this with little expense could be greatly improved. In a small island near Sardina the Italians have entirely stamped malaria out, simply by draining one or two little swamps, and there is not the slighest doubt that in a few years there will not be half the malaria in Italy, so energetic is the action of the authorities there.

Major Ross has started for the West Coast of Africa to try and rid one of the towns there of fever. If the expense is not too great and the town lends itself to drainage there is no doubt he will succeed. This again is an instance of local action and if one can live in one single spot in the West Coast of Africa without getting fever, so much has been gained.

Subsidiary to these great points at issue comes the private prophylaxis by means of mosquito nets, mosquito proof houses &c.

No one should ever sleep in the tropics without a mosquito net. Though not absolutely a safeguard, especially if faulty in construction, yet it prevents many bites of insects other than mosquitos, and undoubtedly reduces the risks of acquiring such diseases as filariasis and malaria.

The question of mosquito-proof houses answers exceedingly well for the sub-tropics and in a few years there will be few if any unprotected houses in the malarial parts of Italy, the Government of that country last year having passed a bill that all employers of labour must provide protected houses for their employèes, and people of independent means are only too glad to go to the expense of the wire netting to escape attacks of fever. The question of such houses for the tropics is more difficult, the present mode of construction rendering it no easy task to fit them up with wire netting, and then there is the belief, whether true or not, that such protection cuts off the air, a very important factor in life in such climates. Be that as it may if people are to live in the very worst parts of the tropics, such as the unhealthy country part of the west coast of Africa, it is difficult to see how else they are to exist. In the hot season in Italy the temperature is often over 90° and it is quite as hot, though with less humidity in the air, as the tropics, and yet the people don't complain specially of the houses being any hotter with the gauze netting than without. The plan of having verandahs of netting is a good one as the people can then sit out in the hot part of the evening with impunity, and can dine or have their other meals there. Sir William MacGregor, the Governor of Lagos, took out some specially prepared houses and wire netting to that colony last year and the experience of the people who live in them will be of interest, and will act as a guide to their adoption in other parts of the west coast, and other tropical colonies.

To conclude then, we definitely know now the cause of malarial fever and its spread from man to man : it is a preventable disease, and the struggle against it will increase year by year; in some countries, this will be successful owing to peculiarly favourable circumstances as regards locality, the race of people, climate &c. Whereas in others, owing to the absence of these, it will linger on and still cause a large mortality, though even in those less favoured places a judicious combination, intelligently carried out, of the means now known to combat it, should in the long run at least greatly reduce it, if not entirely stamp it out.

FILARIAL DISEASES WITH SPECIAL REFERENCE TO THEIR SPREAD BY MOSQUITOES.

The following is the Paper read by Dr. Low at the meeting of the local Natural History Society of *Barbados* on the 12th instant:—

The part played by insects in the spread of diseases, has in recent years become of so great importance, that I propose to-night to give you a brief description of one of those diseases, with special reference to its means of communication from one person to another. I refer to one of the most common of tropical ailments, namely, Filariasis. I do this with special pleasure, as it was largely due to Dr. Manson's researches on this subject in its relation to mosquitos, that the suggestion came to him in after years that Malarial fever might also be spread by similar insects.

Zoologically the filariæ belong to the natural order *Filaridae*, a member of the class Nematodes or round worms, which in turn is a sub-division of the large group Nemathelminthes. Besides those infecting the human subject numerous other species are known in the lower animals, some closely resembling the former in their structure and life histories, while others are entirely different. Dogs harbour at least, two well known species, namely: *Filaria immitis* and *Filaria recondita* the intermediate hosts of which have been so ably demonstrated by the eminent Italian Zoologist, Grassi, and many birds are also infected with similar parasites. Four distinct species are known in man at the present day, and if the adult worm described by Magalhaesi in 1886 be taken into account, a fifth may be said to exist. Those are as follows: 1. *Filaria Nocturna* 2. *Filaria diurna* 3. *Filaria Demarquaii* 4. *Filaria perstans* and 5. *Filaria Magalhaeis* which is doubtful.

The parental forms of those worms inhabit the lymphatic system or connective tissues of man; theyare viviparous, giving birth to young embryos which pass into the blood, where they swim about often in great numbers and have no further power of development until they are abstracted from that medium by their proper intermediate host.

Filaria nocturna (Manson), the *FilariaSanguinis Hominis* of Lewis, is the commonest of all those and the best known. Its life history, parental forms, pathology and anatomy have all been worked out, and as far as our present knowledge of the subject goes, is the only one that definitely causes pathological changes in man. We shall therefore take it up and follow it through its various phases, starting with a brief historical sketch.

Demarquay in 1863 was the first to describe the embryos of F. nocturna. In that year he had occasion to operate in Paris on a young man from Havana for a lymphatic tumour, and on microscopically examining the fluid removed was astonished to find several very minute cylindrical worms amidst the pus cells and other debris. He published an account of this in the Medical Gazette of Paris of that year, and gave drawings of the parasites, but the discovery attracted no attention and was soon forgotten.

Wucherer in Bahia rediscovered the embryos in somewhat similar cases in 1866, but did not hazard an opinion as to what they were, or as to whether they had anything to do with the disease. No real advance was made in the subject till Lewis, in India, in 1872, discovered similar embyros swimming about in the blood of a patient, whom he was examining to see from what disease he was suffering. On account of their position he named them the Filaria sanguinis hominis, a name which was adopted though afterwards changed in recent years by Manson, when it was discovered that this was only one of many worms which inhabit the blood of man. By this time every one working at the subject was agreed that those small actively moving worms seen in the blood, were only young or embryonic forms of an adult form, lying somewhere or other in the body of the host, and observers began to search systematically to find them. The honour eventually fell to Bancroft, in Brisbane, Queensland. While opening a lymphatic abscess in the arm of a patient one day, in whose blood filarial embryos had been demonstrated, he found a small worm about 3 to 4 inches long and the thickness of a human hair. Obtaining several more soon afterwards from another case he sent them home to England to Cobbold for identification, and the latter, on examining them, found many embryos in the uterus of one, which were exactly similar in measurements and structure to the specimens seen in the blood of other cases. This settled the point and definitely proved that the young forms found swimming free in the blood of people suffering from filarial disease, were the offspring of parent worms living in the lymphatic trunks.

The next important advance in the subject took place in 1878, when Manson, in Amoy, in China, discovered that certain species of mosquitos acted as intermediate hosts for the further development or metamorphosis of the young filariæ. Struck by the fact that the embryos in the blood showed no evidence of growing or in any way

changing, he was led to the belief that in some way or other they must get into an intermediate host to allow of their further development, as is so common amongst the various forms of parasitic worms. Starting on this basis he began to examine different suctorial insects, which were known to have fed on filaria infected cases, and amongst those mosquitos formed a large part, as they were very prevalent in the district.

In all of those examined he found that the filaria were ingested with its blood into the stomach, but that in most of them they were slowly digested and disappeared. Only in the case of a small brown unstriped mosquito, nocturnal in habits, this did not hold good ; instead of being digested some of the parasites bored their way into the tissues of the host, chiefly the thoracic muscles, and there underwent a most remarkable development.

To make this out definitely Manson conducted a series of carefully worked-out experiments. He persuaded a Chinaman who had filarial embryos in his blood to sleep in a specially erected wooden frame work covered with mosquito netting ; at nights the door was left open and after a number of mosquitos had entered, was closed. In the mornings the gorged insects seen hanging on to the netting were carefully caught and put in stoppered bottles, and there kept till required for examination. Three species of mosquitos were in the habit of visiting the house, two were of the variety known as the tiger, sooty in colour, with white bands on their legs, while the third was a small brown insect, probably *C. Pipiens*. In the case of the latter the migration to the thoracic muscles was noted and then the metamorphosis was traced out, insects being dissected daily and the changes noted. He found that in about 8 days the embryos had attained an enormous size, $\frac{1}{16}$ of an inch in length by $\frac{1}{850}$ of an inch in breadth, and further now possessed an alimentary canal and other structures. Most of the insects now died, and Manson put forward the view that in nature the mosquito, after laying its eggs on the water, died there and disintegrated, thus freeing the young embryo, which could live in this medium until taken up by man, when it would, by boring the stomach, gain some lymphatic trunk and there become the mature parasite.

Confirmation of this remarkable discovery was soon to hand. Lewis in India began a systematic research, and was astonished to find that when care was taken 14 per cent of the mosquitos taken at random round about his house contained filarial embryos. He followed out Manson's experiments, but did not describe forms later than the 4th or 5th day, most of his mosquitos then dying. Sonsino, in Egypt, in 1882 did similar work but did not see such advanced forms as the former two observers.

For many years nothing further was done in the subject till Grassi in 1890 indirectly confirmed the insect phase of the filaria of man by finding out that the embryos of the Filaria recondita of the dog undergo a metamorphosis of a similar character in fleas.

Briefly stated, Filaria recondita is a filarial parasite of the dog the mature worms of which have been found lying in adipose tissue near

the hilum of the kidneys. Its embryos live in the blood and various kinds of fleas especially the dog flea, Pulex serraticeps, ingest them when feeding. The young parasites bore their way through the intestine and stomach of their host and find their way to the adipose tissue where they embed themselves in the fat cells. While here they undergo four stages of development and eventually become almost completely mature. Grassi tried feeding dogs with infected fleas, but got negative results.

In 1899, Bancroft (jnr.) in Australia, worked out afresh the metamorphosis of Filaria nocturna in the mosquito, and not only verified completely the previous discoveries, but also amplified and corrected them in some very important details.

Before starting his work he made a special study of the habits of mosquitos, and found that to keep such insects alive for any length of time it was necessary to feed them on suitable juices or fruits. He began his series of experiments by first rearing large numbers of young mosquitos from eggs taken from water, and when those became insects they were fed on a girl with filaria in her blood. Serial dissections of such insects day by day showed that the final metamorphosis in Australia was reached by the 16th or 17th day, most of the mosqitos easily living for this period of time when fed on bananas and similar fruits. More important than this, however, were his experiments on dissecting mosquitos with metamorphosed embryos in them, in water, so as to allow the contained parasite to escape into that medium. He found that they only lived for 3 to 4 hours, and so came to the conclusion that water was injurious to them, and not the medium by which they are transmitted to man, the final host. On those grounds he brought forward two theories: firstly, the accidental swallowing of mosquitos, which seemed highly improbable; and secondly, a suggestion that the filariæ might come out by piercing the oesophagus of the mosquito when it was sucking blood, and so get into the system of man through the skin. Bancroft, at this same time, made a large collection of filariated mosquitos, preserved them in glycerine and sent them home to Dr. Manson to the London School of Tropical Medicine.

While working there on this material last year, I was able to demonstrate the means of escape of the young *filaria* from its intermediate host the mosquito, namely through the proboscis of the insect, thus disproving the water transmission theory and making filariasis a directly inoculable disease. Those conclusions were reached by making serial sections of mosquitos with a microtome after embedding the insects in celloidin. By this means it was found that the young *filariæ*, after reaching their highest stage of development in the insect, instead of lying passively in the thoracic muscles, leave that tissue and travel forward in the direction of the head of the mosquito, and pass into the loose cellular tissue which abounds in the prothorax in the neighbourhood of the salivary glands. After a short stay there they pass into the head, remain for some little time in the loose tissue below the cephalic ganglion and then pass into the proboscis where they lie awaiting the opportunity of gaining access again to man when the mosquito bites.

Working simultaneously in India, Captain James, of the I.M.S., while dissecting fresh mosquitos, also found a completely metamorphosed *filaria* in the proboscis of one of these insects. The proboscis view was very quickly corroborated by Grassi in Italy, who traced the embryos of *F. immitis*, one of the blood worms of the dog, through the common *Anopheles claviger*. He found that the embryos developed in the malpighian tubes and not in the thoracic muscle, where after a stay (in the mosquito) of about 10 days they become completely metamorphosed, migrate to the head of the insect and pass into the proboscis. By direct infection experiments on healthy dogs he found that the worms passed from the proboscis into the tissues of the dog and disappeared. His views on the exact position of the parasites in the proboscis differ slightly from mine but they in no way interfere with the main issue, namely the fact that the worms passed directly into the human host.

The Geographical distribution of *Filaria nocturna* is tropical and to a lesser degree sub-tropical. Its greatest prevalence is between the latitude of 30° North and 30° South, that is roughly speaking in those regions with a higher mean temperature than 70° F. such a high temperature not being however absolutely essential for its development, as it has been found spreading well into the subtropical regions. The probability is however that in such places as Charleston in North America, Carthagena in Spain, Brisbane in Australia, it has been introduced by the sea route, from the tropics, has found a sufficiently high temperature at part of the year for its development in the mosquito and has thereupon remained and become indigenous. It has been found in the old world in Asia, Japan, Cochin China, Malay Peninsula, Hong Kong, India, &c., in Africa, in Egypt, in the North Nigeria Congoland, and on the West Coast, and Zanzibar on the East Coast, in Australia in Brisbane and district while such islands as Madagascar, Mauritius and New Caledonia, also possess it. In the new world it has also a wide range from Charleston in North America down to the Brazils in the South, this including the West Indian islands from Cuba to Trinidad ; in the South Sea Islands, Samoa, Fiji, &c., its prevalence is very great.

THE LIFE CYCLE OF THE WORM IN DETAIL.

I think it will be best to begin in tracing the life history of the parasite, with the parental or mature forms which inhabit the lymphatic system and which must not be confused with their embryos which live in the blood.

The parent *filariæ* then are long, hair like transparent nematodes, three to four inches in length, the sexes being distinct, and living together in some part or other of the lymphatic system. Here they may lie coiled up and tightly packed in cyst-like dilatations in the distal lymphatics or they may lie more loosely in the pelvic or other central lymphatics often in varicosities which they have formed by their presence there or they may inhabit the glands or even the thoracic duct itself.

The female *filaria* is larger than tho male, both in length and thickness, measuring 3·4 inches in length *i.e.* 76-100 mm. by $\frac{1}{90}$, $\frac{1}{123}$ *i.e.* ·288 to ·211 mm. in breadth. The latter only reaches a length of $2\frac{1}{2}$-3 inches and is also finer; they are visible to the naked oye, resembling fine cat gut. In both sexes the head is club shaped, with a simple circular mouth showing no evidence of papillae, and joined to the body by a somewhat narrow neck. The body cavity in which the internal organs lie is enclosed by a longitudinal layer of muscular fibres covered by a smooth cuticle with no striae. It contains a well formed alimentary canal and the generative organs which in the female are very large and occupy the greater extent of the body. Seen at this time the body of the female worms are seen to be packed with somewhat avoid shaped eggs, a little embryo comes out of each of those and is born alive into the lymph stream from where it passes *via* the thoracic duct into the blood circulation. The first stage in the life history is thus reached and we shall now follow the life of the embryo in the blood stream.

If one takes a drop of fresh blood at night from a person with filarial embryos in his circulation and examine it under a low power of the microscope he will at once be struck by seeing little snake-like organisms wriggling about in a state of great activity and constantly agitating and knocking about the red blood corpuscles in the vicinity. At first the movements are very active, but after a time they slow down, and then we can see that the little creatures are exactly like miniature worms or eels. Though not changing their position on the slide they coil and uncoil themselves, tie themselves up into knots, then untie themselves again, and probe about amongst the corpuscles with their heads. If one's preparation is ringed with vaseline to keep the blood moist those movements can be watched daily, as the young embryos will keep alive even in such disadvantageous circumstances for 7 to 8 days. On examining them with a high power many interesting features in their anatomy can be made out. It is then seen that they are cylindrical with a rounded head and a fine tapering tail. Further, a fine sheath which can be seen protruding from the head or tail end encloses them as in a sac. A mouth is present and a central column of cells, but apart from those, there is not much more structure to be seen. They measure $\frac{1}{80}$ of an inch in length by $\frac{1}{3000}$ of an inch in breadth, that is, about the diameter of an ordinary red corpuscle How long each individual one can live in the blood stream is unknown, but it must be remembered that they do not grow or develop in any way while here. During the day they disappear from the peripheral blood and collect in the blood vessels of the lungs only again to return as night appears. Why they should do this, and how they have the power to retain their position in the inner vessels against the current of blood, has not yet been found out. Their gradual appearance as evening comes on, in the peripheral blood is exceedingly interesting and can be accurately watched by examining the blood of an infected person every four hours for a day or two. Let us start such a procedure, say, at 12 noon, the drop of blood on examination under the microscope will then shew nothing. A similar one at 4 p.m. will also show nothing, but in the one at 8 p.m. several embryos will easily be

detected, at 12 midnight the specimen will be swarming and at 4 a.m. the numbers though decreasing will still be high. By 8 a.m. only stragglers will be seen, and by 12 noon, where we started, there will again be nothing. This exceedingly interesting feature, termed *filarial periodicity*, was supposed by Manson who discovered it to be an adaptation to the nocturnal habits of the mosquito, the intermediate host. Whether this is so may be questioned, because in the blood worm of the dog *F. immitis* which is spread by an *Anophele* also a nocturnal feeder, this periodicity only partially exists, embryos being found in the peripheral blood at any time of the day.

The second stage in the life history of the parasite is now reached, and this leads us on to perhaps the most interesting period of its life, namely, the extracorporeal phase in the mosquito, the intermediate host.

Naturally every blood-sucking insect that imbibes the blood of a filarial patient at night, must necessarily swallow large numbers of embryos; but the vast majority of such insects do not act as efficient hosts; *i.e.* they are incapable of allowing of the development of the filariae in their tissues; as the blood is digested so are the parasites, and they entirely disappear. A second class are the partially efficient hosts; in their case the embryos not only migrate from the blood of the stomach to the thoracic muscles but even undergo a slight development which is, however, slow, and ends in nothing, death and absorption eventually taking place. Many species of mosquitoes act in such a manner.

The next or 3rd class are the completely efficient hosts, in them the complete metamorphosis of the *filariae* takes place and eventually they are capable of reinoculating man. Several speceis of mosquitos as far as our knowledge at present goes come under this category. Manson found a small brown mosquito in Amoy perhaps *C. pipiens* efficient, (in fact the insect he used when he made his important discovery) while Bancroft in Australia found *C. ciliaris*, the common house mosquito of those parts, was the one that spread the disease. James in Travancore found *Anopheles Rossi*; the second expedition of the Liverpool School of Tropical Medicine discovered an *Anopheles* on the West Coast of Africa to be also efficient, and since coming to the West Indies I have worked out the complete metamorphosis in *C. fatigans*, the common brown mosquito of Barbados and the other islands. Possibly as time goes on more will become incriminated but up till now these are the only ones. The two common house mosquitos of the West Indies then are *C. tæniatus*, a blackish grey insect with white bands on its legs, and *C. fatigan* which is brown; the former fortunately is incapable of spreading the disease but the same cannot be said of the latter, and we shall follow the metamorphosis of the *filaria* through it, as it is the one of the most interest to you here. Starting with mosqustos reared from larvæ so as to be sure of an uninfected stock, one allows these insects to feed on a filariated patient at night and then keeps them in houses with bananas as food till they are required for dissection. If we examine one of these 12 hours after feeding it will be seen that the stomach is gorged with blood distending the abdomen and colouring it a dark

red colour. On squeezing this blood out in a little $\frac{3}{4}$% salt solution and on examining it under a low power of the microscope the embryos are seen actively moving among the corpuscles which have so far undergone very little change. As the blood becomes gradually coagulated and flakey the embryos first shed the long collapsible sheath in which we saw them enclosed in the specimens examined from the human subject, doing this by pressing against the head end of it, which ruptures and then squeezing themselves out till they are free. Once free, they bore their way through the walls of the stomach, pass into the cellular tissues, and make their way to the muscles of the chest or thorax where they pass in between the fibres and settle down to rest. Those changes are accomplished by the end of 24 hours, and in 36 hours (on dissecting one of the mosquitos) one finds the blood all gone from the stomach and the muscles full of embryos which even at this early date have begun to show evidence of growth. From now onwards a most remarkable development takes place. The first thing that is noticed is that the cells of the body begin to multiply and the worm gradually begins to broaden out. In 4 days this broadening has gone so far as to make the appearance like that of a sausage, and by this time the first differentiation of the cells in the body to form the alimentary canal is noticed. The sausage now begins to elongate out and by the end of 6 days is more cylindrical, very little increase in breadth taking place, after this date. By $7\frac{1}{2}$ the structure is very definite, there is a simple circular mouth, the central cells have divided up to form a distinct alimentary canal and have become sharply differentiated from the subcuticular cells which are becoming smaller, and which will eventually form the musculo-cutaneous layer. A fine cuticle encloses the body and this may be seen ending posteriorly in a fine point. Movement though existing is sluggish and consists of a lateral side to side motion. Eight and a half and $9\frac{1}{2}$ days after infection shows a rapid increase of length with a better differentiation of the organs of the body and movement becomes more marked. By $10\frac{1}{2}$ days the length of the embryo has reached $\frac{1}{20}$ inches and is practically mature. Next day, that is $11\frac{1}{2}$ days after biting the infected patient, the metamorphosis is complete and one then finds many of the embryos free from the muscle in the tissues of the prothorax head and neck, and in the proboscis.

They now measures $\frac{1}{16}$ of an inch in length, 1·60mm. by ·024-·032mm. in breadth, the mouth is still simple, an oesophagus expanding into a bulb opens into the intestine which extends along the body to within a short distance of the tail, the latter organ consisting of three distinct lobes. A musculo-cutaneous layer is seen under the cuticle and there is some differentiation of cells to form the generative organs not sufficiently developed however, to tell the sexes from each other. The movement is characteristic, the embryos now actively coiling and uncoiling themselves, twisting and lashing about in a very similar though exaggerated manner to the immature parasites in the human blood. At this time they leave the muscle entering the prothorax and passing from there along the inferior surface of the neck to the under aspect of the brain from where they reach the proboscis. When the mosquito next bites they pass from this latter site, under the skin of the person punctured,

make their way to some lymphatic trunk, there they increase still further in length, become sexually differentiated and then we reach the point from where we started, namely, the mature form in the lymphatics. Such then is the life history of this interesting parasite and all that remains now is to give a short description of the diseases caused by it and the prophylaxis or means by which we may prevent it.

It must be distinctly remembered that the embryos which circulate in the blood as far as is known, give rise to no pathological changes; it is only the parental forms lying in the lymphatics that do so, and the diseases which they cause, originate from injury to this system of the body in which they live. In the majority of cases happily they have no prejudicial effect, that is to say in a systematic examination of the blood of 100 individuals in a filarial district one may find several of those with filarial embryos circulating in their blood and yet showing absolutely no trace of disease or of the presence of those parasites. In a certain proportion of cases, however, various different types of changes may be met with, such as lymphatic swellings lymphangitis, the fever and ague of Barbados, and elephantiasis. The exact manner in which the parasites cause those conditions has not yet been fully worked out, but, according to Manson, in some instances, a single worm, or a bunch of worms may plug the thoracic duct (*i.e.* the tube into which the lymphatics open) and act as an embolus, or originate a thrombus (*i.e.* a coagulation of the lymph behind the seat of obstruction.) In other instances the same authority thinks that the worm may give rise to inflammatory changes on the walls of the vessels and so lead to an obstruction with consequent stenosis and thrombosis.

Whichever form of obstruction takes place, the lymphatic areas drained by those vessels are cut off from the general circulation and then the lymph collects behind, enlarging the lumen of the tube and causing what are called varicosities. This explains the origin of the different lymphatic swellings but not altogether that of elephantiasis; here in addition to the lymph stasis inflammation is also necessary.

In connection with this latter pathological condition it is very interesting to note that the young filariae have disappeared from the blood, the explanation of this being that the parent worms after blocking up the vessels have either died, or have so completely obstructed them that the embryos can now no longer pass into the circulation. However originating, the disease is permanent and cannot be cured, treatment only alleviating the condition, and, such being the case, prevention is the thing to be sought after and this in earnest.

The subject of prevention is a large one, but much may be hoped for by attending to simple methods and means. Manifestly every person with living and active embryos in his blood is a danger to the other people living in the same house and vicinity, not directly as I have shewn you, but by infecting the special species of mosquitos which are efficient to allow of development taking place in them. Those infected mosquitos live and frequent the house, biting fresh people every day or so and eventually, when the parasites have arrived

at maturity, inoculating them. Such cases should sleep under properly applied mosquito nets so as to prevent as far as possible this great danger. The next point theoretically is to get rid of all mosquitos about houses, but this practically is by no means an easy task. How are we to attack those pests? One must look into their life history to see which is the most vulnerable point to strike at them. *Culex fatigans*, the common mosquito of Barbados, is a small brownish yellow insect, the males being harmless *i.e.* not biting, and being distinguished by their more slender build and feathery antennae. It is essentially a domestic mosquito not being found far from houses, and is nocturnal in its habits, sleeping by day in the darkest part it can find and starting forth just about sunset for its night's work. Its presence when near one can be readily detected by its humming noise, and then choosing an exposed part it gently settles and proceeds to bite, remaining if not disturbed for a considerable time, sucking up the blood. When finished, it is gorged and heavy, and rising slowly seeks some quiet spot where it may sleep off the effects of its meal. In this condition it remains for a day or so till all the blood is digested, and then it is ready to start afresh. The eggs of this species are deposited in what have been called boat-shaped masses, in water barrels, tanks or other similar collections in the vicinity of the house. In about two days each egg gives rise to a small larva which swims about in the water and grows rapidly, feeding on the animalculæ and other organisms to be found there. They breathe by a long tube at the posterior end of the body, and have to come to the surface to allow of the contact of the air, their position then being perpendicular or at an angle with the head hanging downwards. In 12 to 15 days according to the temperature they change into the pupæ or chrysalis ; they now cease to feed, and the respiratory tubes are altered in position now being found on the dorsum of the thorax. Two days are spent in this phase and then the skin splits down the centre of the back and the imago or perfectly formed insect emerges, rests for a little on its cast-off case, and then flies away. To diminish or to completely eradicate mosquitos from a house then two ways are open, either to have no collections of water for them to breed in, or if such cannot be done away with, to render them harmful to the insect so that it can no longer develop in it. In plain words then no uncovered water barrels, wells, tanks or collections should be allowed near one's house, especially, as is the case in Barbados, where there is such an abundant pipewater supply. For the second alternative where tanks or fountains will be necessary, say, for example, in gardens, etc., several means may be adopted. The tank should have a properly fitting cover applied so as to prevent any mosquitos getting in to lay their eggs, or if this is impossible, kerosine should be applied to the surface of the water every week. The rationale of this is simple The oil forms a fine film over the surface of the water, preventing the larvae getting access to the air and so suffocating them. If water from such a site be drawn off from a tap at the foot of the tank the film is not broken but remains, and the water is perfectly good for washing purposes and for plants. Small fountains in gardens can be treated in a similar manner, or gold fish, which feed greedily on the larvae can be put in them. *By such*

simple means then a house which was before infested by mosquitos can in a very short time be rendered almost entirely free. It is by striking at the larval stage that we can hope for the best results, as the destruction adult insects is a much more difficult affair.

For individual prophylaxis *the use of the mosquito net must be adopted, but by this I mean the proper use.* It is no uncommon sight to see mosquito nets full of large holes large enough to let dozens of mosquitos in. Many others are applied, the edges hanging down by the sides of the bed, and not reaching the floor, leaving a sufficiently large space for all sorts of insects to crawl in by. The net should be suspended from the roof, should be lowered after the bed is made in the morning, should be tucked carefully in below the mattress all round, and then one should get under it as quickly as possible when going to bed, seeing again when in that it is properly applied. One may of course be bitten in the evenings before going to bed, but it is during sleep that there is the greatest danger, because then the mosquito has time to suck at its leisure without being disturbed.

To sum up then, our hope of diminishing this dreadful disease is by prevention, to be attained, as far as possible, by some of the means and methods I have indicated to you above.